THE BRITISH VETERINARY JOURNAL

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Vol. 110 **January, 1954** **No. 1**

EDITORIAL

FERTILISERS, LEY FARMING AND DISEASE

DURING the last 150 years a great change has been taking place in agricultural science and practice. Ideas and methods, which have served since man turned his attention to the soil and ceased to depend for his sustenance upon his prowess as a hunter, have been revolutionised completely. This revolution has been impelled by two prime factors: first, the great increase in the population, and secondly, by the urgent necessity to increase the yield of food from the soil. When the areas available for tillage are static or restricted each plot must produce to its maximum quota. This can be done consistently and continuously only if the fertility of the soil be preserved and enhanced.

The first milestone in the attainment of this goal was erected when the system known as "Rotation of Crops" was evolved. This great discovery became the "keystone" of British agriculture and remains so even to the present day. Good rotation means higher yields, better quality of crops and moreover it conserves and improves the fertility of the soil. This wonderful system or method did not come about as the result of the planned design of some scientist but by the "empirical" adventures of men wedded to the soil who could see and note the response of a bountiful nature. Their methods were those of trial and error and they could not explain the wonderful phenomena in scientific terms. The world has witnessed many such incidents and, as is often the case, the scientists, being presented with the facts, can by "working back" supply the correct explanation.

(*The December issue of The British Veterinary Journal was published on December 7*)

The system of rotation has been subject to modifications from time to time but the basic principles on which it is founded remain sound and secure.

The German chemist Liebig was responsible for the first great change or modification when in 1840 he published a paper on " Chemistry in its application to Agriculture and Physiology." It is said that his theme, " That all the requirements of a plant could be supplied by mineral salts," was interpreted too literally and this led to abuse. The immediate and sometimes spectacular economic gain which follows the application of " chemical " fertilisers bid fair to thrust aside the methods which had served so well in the past and which had been evolved by virtue of experience and practice throughout the ages.

In more recent times another modification has achieved great popularity, i.e., ley farming. This method is not entirely new for it has been practised in a restricted form for many years and particularly in Scotland. The present widespread adoption of this system results from the wartime urge to increase yields and the post-war necessity to fortify agricultural economy.

Scientists in their wisdom have entered the fray. They tell us what to do to the soil, what crops and plants to grow and they indicate the fertilisers which are likely to pump energy into the land and urge it to greater and greater effort. As was the case when Liebig's methods were followed, ley farming as dictated by the scientists does give results and brings economic benefit. It would be true to say that ley farming was mainly responsible for the great increase in the output of our farms during the recent war and in the aftermath.

The original rotation method of cropping was a modification of nature's design for preserving the fertility of the soil, and improving the yield and quality of the crop. Liebig's methods and ley farming represent man's interference with a natural process. If such interference does not offend nature then permanent and good results can be expected. When the interference is contrary to natural law the good effects may be only temporary and may lead to exhaustion of the soil and serious effects upon the yields and nutritive value of the crops.

Good health in the animal and vegetable kingdom depend on the quantity and quality of the nutritional intake and probably quality is the most important factor. In recent years new diseases have been noted in plants and animals and others seem to have increased in their incidence. Some of these troubles are of the neuro-somatic type; others can be traced to some metabolic upset. In man the increased incidence of some dysfunctions appears to coincide with the era of the " Tin Can " and in animals there seems to be some connection between certain diseases and the use of artificial fertilisers and the advent of ley farming.

It is fair to say that positive proof of any correlation is lacking but suspicion remains. As a general rule, " Where there is smoke there is fire," and the matter between fertilisers, ley farming and disease calls urgently for investigation.

GENERAL ARTICLES

THE INFLUENCE OF FERTILISER TREATMENT OF GRASSLAND ON THE INCIDENCE OF HYPOMAGNESÆMIA IN MILKING COWS

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Introduction

It is sometimes stated that the various metabolic disorders, including hypomagnesæmic tetany are more common in dairy cattle where an intensive system of ley farming has been introduced. Evidence on this point is, however, scanty and where it is available, is usually in the form of reports of cases on commercial farms rather than findings produced experimentally under controlled conditions.

A major aspect of intensive grassland farming is the heavy use of artificial fertilisers and this paper reports some initial results of experiments planned to find out if hypomagnesæmia can be associated with specific fertiliser application.

A direct approach to this problem is difficult since the physiological mechanism which controls the level of blood magnesium is not known. Hypomagnesæmic tetany and hypomagnesæmia without clinical symptoms have been reported in cattle of both sexes at all ages, and at various seasons of the year while at grass or inside on stall rations. The investigation to be described is concerned with the hypomagnesæmic tetany which occurs frequently in dairy herds within a few days of the cows being turned out to grass after a winter period of stall feeding. This acute form in which a sudden fall of serum magnesium is associated with symptoms of hyperæsthesia may be followed by convulsive tetany and death; it was first reported by Sjollema and Seekles (1929) and was termed " grass tetany." The occurrence of hypomagnesæmia with and without clinical symptoms on a grass diet containing, by some accepted standards, adequate magnesium, the sudden appearance of the disorder within a few days of being turned out to grass, and the fact that pasture usually provides a higher intake of magnesium than a hay and cereal stall diet on which dairy cows are much less prone to hypomagnesæmia than on pasture, all suggest a physiological dysfunction rather than a nutritional deficiency of magnesium. There is, however, some evidence (Cunningham, 1934; Blakemore and Stewart, 1935; Allcroft and Green, 1938; Allcroft, W. M., 1947*b*; and Allcroft, R., 1953) that the feeding of magnesium oxide or magnesium-rich mineral supplements has a beneficial effect by " flushing " the animal with excess of easily absorbed magnesium which alleviates, and in some cases prevents, the rapid fall in serum magnesium.

Brouwer (1952) has suggested that the relative proportions of the various base-forming and acid-forming elements in the diet may influence, *inter alia*, the blood serum magnesium level and has provided evidence of a very high proportion of potassium relative to sodium, calcium and magnesium in grass from pastures producing grass tetany.

In planning the experiments reported, therefore, it was decided to include a treatment in which a heavy dressing of a magnesium compound was applied to the sward to try to increase substantially the magnesium intake of cows consuming the herbage; to attempt to simulate a system of very intensive grass production by heavy use of nitrogenous fertilisers, and finally, to study the effect of unusually heavy dressings of a potassic fertiliser.

Experimental

Method of investigation. During recent years it has been found possible to produce hypomagnesæmia in dairy cows at the National Institute for Research in Dairying by changing them directly and quickly from winter feeding conditions to spring grazing. Under the former conditions the animals are housed at night, and their rations consist of hay and usually silage together with a concentrate mixture. While at grass no supplementary feeding was normally given, and the cattle were out day and night. The hypomagnesæmia usually occurred on a simple sward of cocksfoot (S.37 and S. 143) and white clover (S.100). This sward was used because it produced sufficient early growth to allow a full diet of grass immediately after turning out. We have no evidence that it is more likely to produce grass tetany than other grasses.

While a dramatic hypomagnesæmia has often been produced and several cases of grass tetany have been recorded during the last few years under these conditions, the occurrence has been almost entirely confined to the first few weeks of spring grazing. This study therefore relates to two periods of a few weeks immediately before and after turning the cattle out to grass in the spring of 1952 and the spring of 1953.

The experiments were designed principally to study the blood levels of magnesium, calcium and phosphorus, and the incidence of grass tetany. Milk yields were recorded at every milking but since the animals were few in number and in various stages of lactation, they were not suitable for providing information on the effect of the swards on production nor on the effect of hypomagnesæmia on milk yield.

Field layout and fertilisers. The area used consisted of 7.2 acres of a uniform clean sward sown under an oat crop in 1951, the seeding consisting of :—

Cocksfoot S.143	7 lb.	Total 17 lb. per acre.
Cocksfoot S.37	7 lb.	
White clover S.100	3 lb.	

The young sward was grazed in the Autumn of 1951. On February 12, 1952, the whole field was dressed with 2.5 cwt. superphosphate per acre. Following the experiment in the Spring of 1952 the whole area was grazed intermittently by dairy cows during the Summer and Autumn, and on February

24, 1953, 1.8 cwt. triple superphosphate per acre was applied. Early in 1952 the field was divided by electric fencing into three main plots as follows:—

Plot A (Mg+N)*—1.6 acres. On February 22, 1952, 25 cwt. of calcined magnesite (commercial grade containing not less than 87 per cent MgO) per acre was applied. On February 24 and again on March 12, 1952, the plot received 3 cwt. sulphate of ammonia per acre. The magnesite was applied without "slaking" and caused some scorching of the sward. The herbage recovered after a few days but the presence of the magnesite on the surface of the soil caused some loss of nitrogen from the first dressing of sulphate of ammonia.

In 1953 no further magnesite was added but a further 3 cwt. per acre of sulphate of ammonia was applied on both February 24 and March 14, 1953.

Plot B (N)—3.0 acres. This plot was larger than the others in 1952 in order to allow for the grazing of some cows receiving supplementary food as well as those receiving grass alone. Sulphate of ammonia was applied at 3 cwt. per acre on both February 24 and March 12, 1952.

In 1953 plot B was split as follows:—

Plot B1 (N)—1.5 acres. Sulphate of ammonia was applied at 3 cwt. per acre on February 24 and March 14, 1953 (as in Plot A).

Plot B2 (O)—1.5 acres. This plot, used as a control, received no fertiliser other than the basic superphosphate dressing.

Plot C (K)—2.6 acres. This plot received 4 cwt. of sulphate of potash per acre on February 22, 1952, and again on February 24, 1953.

In 1952 the generous application of phosphorus and potash with no nitrogenous fertiliser quickly produced a clover-dominant sward in Plot C. Since it seemed probable that the excessive clover on this plot compared with the other plots might, *per se,* affect the incidence of hypomagnesæmia, it was decided to reduce the proportion of clover on this plot in 1953. On March 24, 1953, therefore it was sprayed with Cornox D (2-4D amine) at the rate of 4 pints per acre. This checked the clover growth over the period of experiment very markedly.

The plots were divided by two parallel electric fences about one yard apart to prevent grazing from adjacent plots. During the experimental periods the cattle were strip folded on their respective plots. A forward fold wire only was used and the cows were allowed to run back over areas already grazed. Liberal quantities of grass were made available to eliminate any complication due to restricted intake and after the folding was complete a few days of general grazing on the respective plots were available.

Cows used. Grazing was started as soon as substantial growth of the sward commenced—on April 17 in 1952, and April 14 in 1953. Growth in both years, especially on the plots receiving sulphate of ammonia, became very

*The letters given in brackets are included in order to identify the plot treatment, and are not intended to signify the rectification of a deficiency in the sward or animal. N=Sulphate of ammonia, Mg=Calcined magnesite, O=Control, K=Sulphate of potash, Concs.=Supplementary feeding with concentrates.

vigorous. It was apparent that additional cows could be carried on the plots for long enough to observe the effect on serum magnesium levels. These cows were added directly from winter feeding conditions.

Thus the total numbers of cows put on the plots were as follows:—

1952	April 17	April 27
Plot A (Mg+N)	4	—
Plot B (N): with supplementary feeding ...	4	—
without „ „ ...	4	4
Plot C (K): clover dominant	4	2

1953	April 14	April 20	April 22
Plot A (Mg+N)	3	2	—
Plot B1 (N)	3	2	2
Plot B2 (O)	3	1	—
Plot C (K): clover suppressed	3	1	—

The supplementary feeding to 4 cows on Plot B in 1952 consisted of concentrates at 4 lb. for each gallon of milk produced. The mixture was dredge corn 2 parts, bran 1 part, and decorticated groundnut cake 1 part.

Shorthorn, Friesian and Guernsey cows were used. All were in milk although most were at an advanced stage of lactation, their yields ranging from 1½ to 3 gallons of milk per day.

Data obtained. Samples of blood from the jugular vein were taken from all cows at least twice per week and, during critical phases, three times per week. Serum calcium and magnesium determinations were made on all samples. Phosphorus determinations were made on the blood from one cow on each treatment on all occasions in 1952 and from all cows about once weekly in 1953.

Samples of the grass were taken from each plot on seven occasions in 1952 and on ten occasions in 1953 as grazing progressed. These samples were taken from the sward immediately before grazing. Near the end of the experiment each year separate samples of clover and grass were taken from each plot. All samples were dried and magnesium, calcium, phosphorus and crude protein determinations were made.

Results

Serum magnesium. The levels of serum magnesium for each cow for 1952 are shown in Fig. 1, and those for 1953 in Fig. 2.

1952. Three of the four cows on Plot A (Mg+N) showed no hypomagnesæmia up to 20 days after going to grass. At this point these animals were transferred to Plot B (N) and two of them showed a rapid fall in serum magnesium, one falling within a week from 2.3 to 0.6 mg. of Mg per 100 ml. serum. The fourth cow in this plot, Peach 28, showed a steady fall in serum magnesium from 2.7 to 0.5 mg. per ml. serum during the first 18 days after going to grass. Although this animal was in no way abnormal in behaviour and appearance, her serum magnesium reached a level which is often associated with symptoms of grass tetany.

Of the four cows on Plot B (N) which received concentrates, none showed the extreme fall in serum magnesium levels which occurred in many of those on the same grass receiving no concentrates and none showed clinical symptoms. The cow Flora 83 which showed the steepest fall had to be withdrawn because of a severe accidental teat injury. Serum magnesium levels in the other three cows showed an irregular slow downward trend but remained above the range in which clinical symptoms usually appeared in the herd. The data from this group strongly support the recommendation, often given in practice, to commence grazing gradually and to feed supplementary dry food for several days after turning the cattle on to grass.

Of the eight cows turned on to Plot B (N) without supplementary feeding, five showed a very rapid fall in serum magnesium to 0.4 or 0.5 mg. per 100 ml. of serum—levels which are considered likely to be associated with clinical symptoms of grass tetany—and, in fact, four of them showed typical symptoms. The fifth showed no tetany or other clinical symptoms apart from some loss of condition and a mild hyperæsthesia, but her serum magnesium remained at about 0.5 to 0.6 mg. of Mg per 100 ml. for more than two weeks. Of the remaining three cows, two (Flora 97 and Pippin 14) showed a less pronounced and slower fall in serum magnesium level, while in the third the level remained well within the common normal range of 1.8 to 3.2 mg./100 ml. throughout. This cow, Bridget, was at the drying-off stage and although diminished lactation may have helped to prevent the dramatic drop in serum magnesium levels which occurred in many of her plot mates, there is no direct evidence to support this suggestion, and it is known that hypomagnesæmic tetany occurs frequently in dry cows and heifers.

Although serum magnesium values in four of the six cows on Plot C (K) fell below the common normal range, the minimum recorded was 1.1 mg. per 100 ml. which is above what appeared to be the danger level for this herd. Two of the graphs for this group are somewhat irregular but all show an upward trend in the later stages of the experimental period. The sward on the potash plot became markedly clover dominant in 1952, and in view of the great difference in the mineral content of the clover and grass on the plots (see below), the serum magnesium levels observed may not represent the direct effect of the heavy application of sulphate of potash, but rather an indirect effect due to an increase in the proportion of clover in the sward.

1953. The results obtained in 1953 confirm the trends found in the previous year. On Plot A (Mg in 1952+N) the serum magnesium level of four of the five cows remained within the normal physiological range during the first two weeks on the plot and that of the fifth cow, Dido, was low (1.3 mg. per 100 ml. serum) before going out to grass but returned to normal within 10 days. After three of the cows had been on Plot A for 25 days and the other two for 18 days, they were all transferred to Plot B1 (N) for 10 days. In all cases there was a marked fall in the serum magnesium within three days. The level in four of the five cows had shown a gradual fall during the four days prior to the change over but not to levels regarded as dangerously low for this herd. It is possible that this

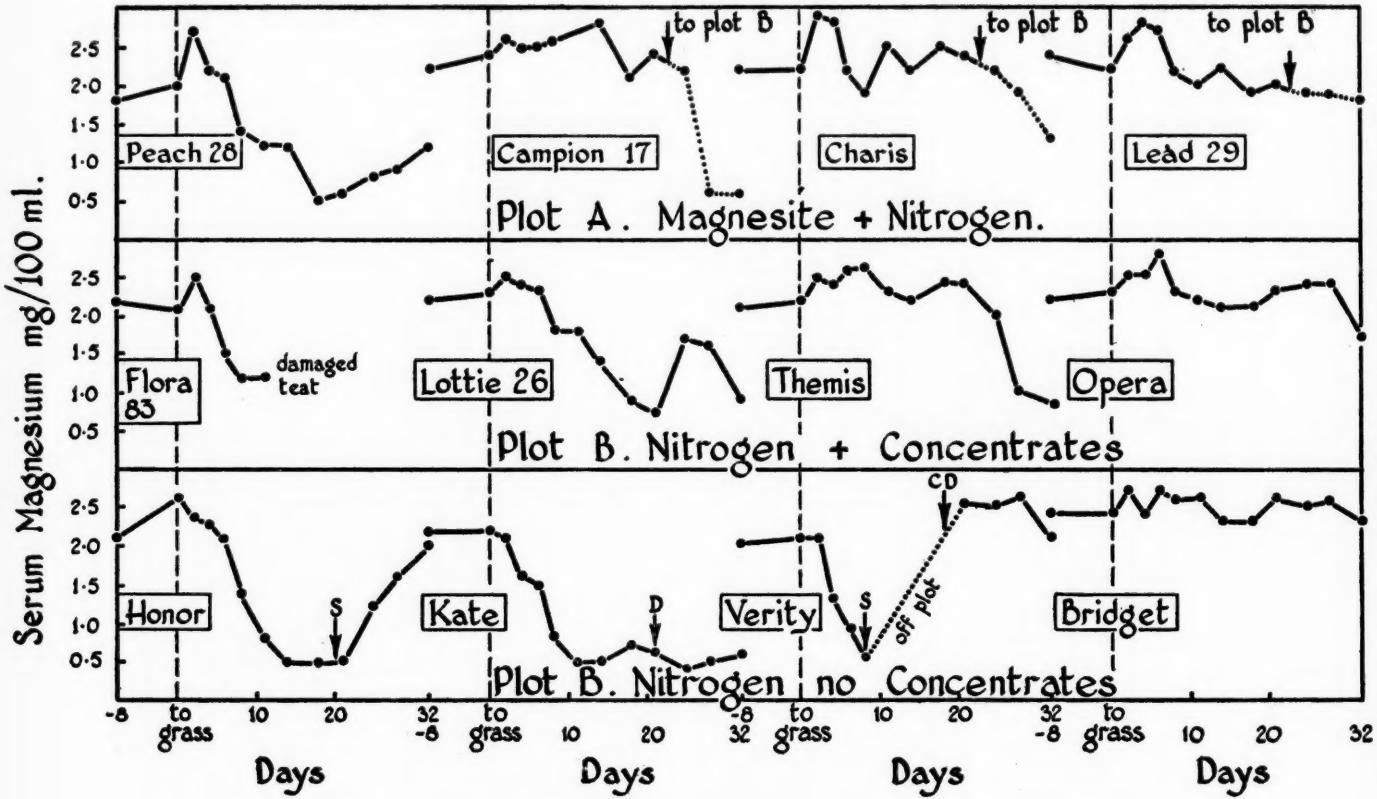


Fig. 1. Blood Serum Magnesium Levels, 1952

S—Clinical symptoms; D—Dosing 4 g. MgO per day; CD—Curative dosing 2 oz. MgO per day.

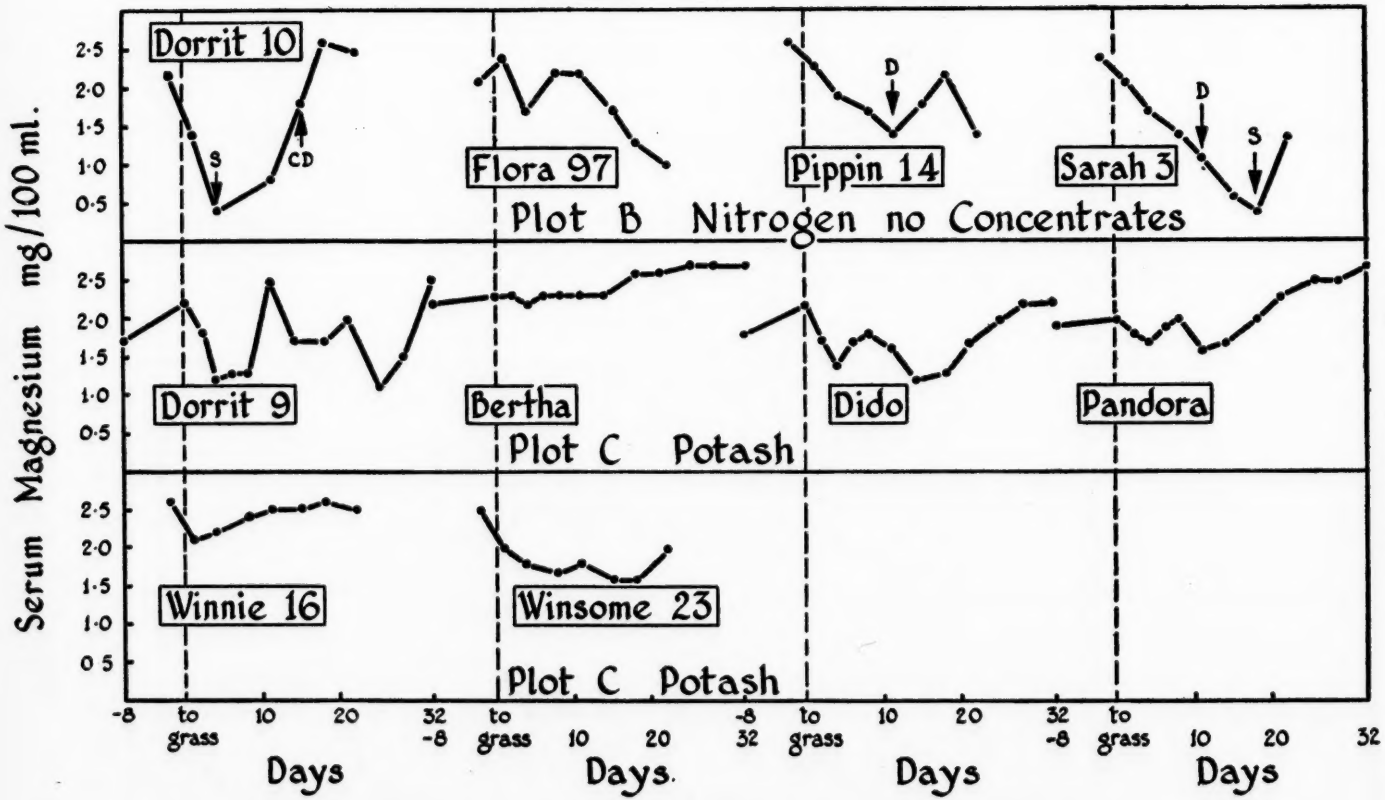
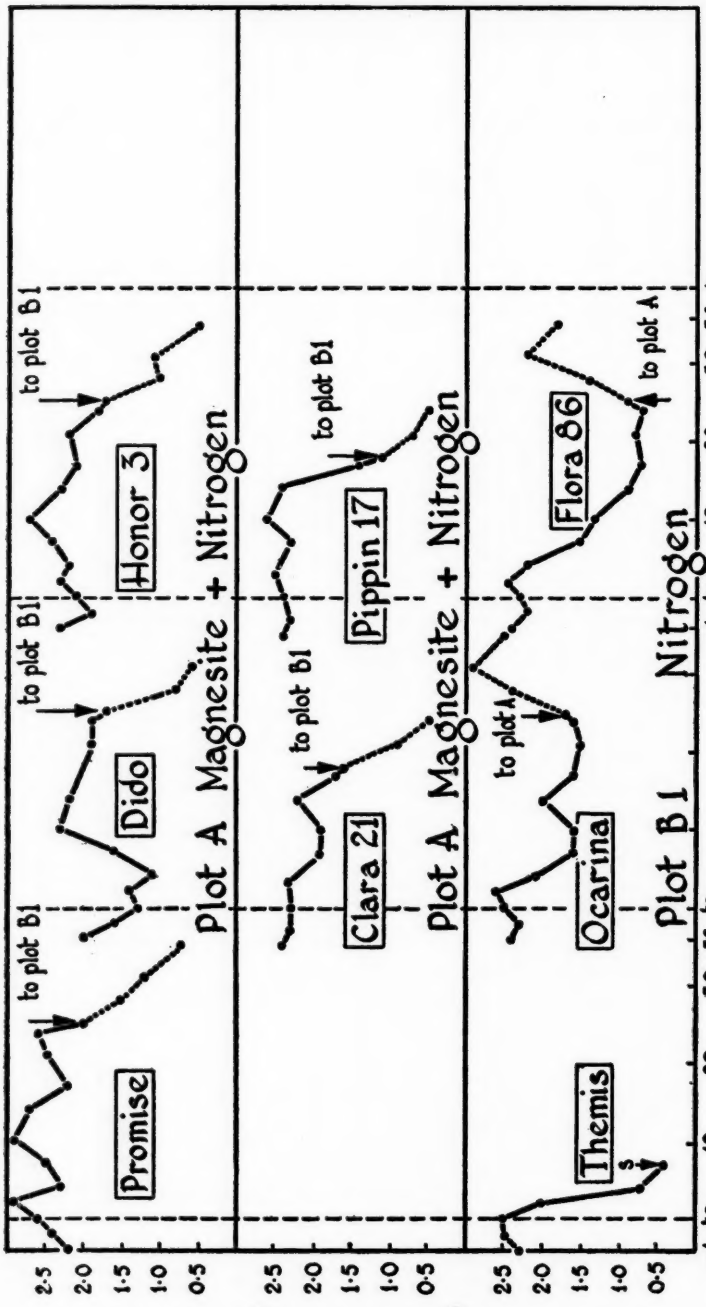


Fig. 1. (continued)

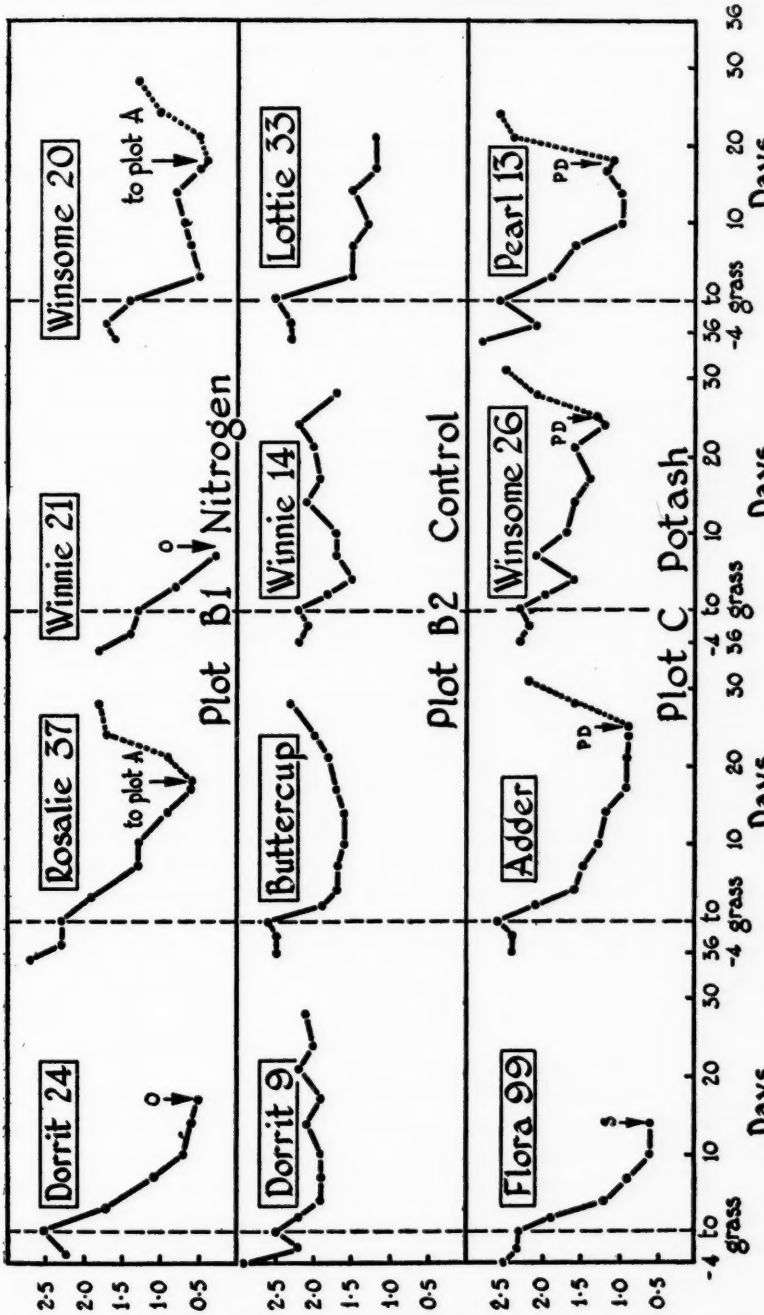
S—Clinical symptoms; D—Dosing 4 g. MgO per day; CD—Curative dosing 2 oz. MgO per day.

Fig. 2. Blood Serum Magnesium Levels, 1953



S—Clinical symptoms; PD—Dosing 2 oz. MgO per day; O—Death.

Fig. 2. (continued)



S—Clinical symptoms; PD—Dosing 2 oz. MgO per day; O—Death.

may have been due to the fact that strip folding on Plot A had finished, and the animals were forced to graze back over land which they had already grazed selectively.

On Plot B1 (N) six of the seven cows showed a fall in serum magnesium, in some cases rapidly, to levels at which clinical symptoms were liable to appear. The seventh cow, Ocarina, showed a slight fall in serum magnesium, but not to a dangerously low level. One cow only, Themis, was actually observed with symptoms of grass tetany, but two cows, Winnie 21 and Dorrit 24, were found dead late in the evening at 7 and 17 days respectively after commencement of grazing. The remaining four cows were transferred to Plot A at the same time as those from Plot A were brought on to Plot B, and this change resulted in a fairly rapid increase to normal in their serum magnesium levels within six days.

Plot B2 (O) received sulphate of ammonia in 1952, but in 1953 it was left as a control and the sward was much less vigorous, had a better clover content, and appeared to be more palatable than Plot B1 (N). Although there was a slight fall in serum magnesium in three of the four cows on this control plot during the first 12 days after turning out, the level remained mostly within the common normal range. In the fourth cow, Lottie 33, the decrease was more marked, but the level did not fall below 1.2 mg. Mg per 100 ml. serum.

Serum magnesium levels in the four cows on Plot C (K) in 1953 were considerably lower than in 1952. These results suggest that the suppression of most of the clover had left a sward almost as capable of reducing the serum magnesium level as that produced on the plot heavily dressed with sulphate of ammonia.

Serum calcium. These data are not given in detail since they appear to add little information concerning grass tetany. In general calcium values remained in the range of 8.0 to 10.9 mg. per 100 ml. serum. It is noteworthy, however, that, with one exception, in the clinical cases of grass tetany (including the animals found dead), calcium levels in the range 6.8—8.0 mg. per 100 ml. serum, coupled with low magnesium values, were recorded within two to three days before symptoms or death occurred. On the other hand, where low serum magnesium values were recorded without any marked change in the calcium values, no clinical symptoms were observed. These observations are in agreement with those of Allcroft, W. M. (1947*a*) who reported that out of 406 cases of hypomagnesæmia, 76 per cent showed concomitant hypocalcæmia.

Clinical symptoms. In 1952 clinical symptoms of grass tetany occurred only in cows on Plot B (N) where no supplementary feeding was given. On this plot four of the eight animals showed typical symptoms. In order to avoid deaths, curative treatment was applied as soon as the first symptoms were seen, and for this reason observed symptoms varied from little more than a condition of mild hyperæsthesia to that of convulsions and prostration.

In 1953, three cows showed clinical symptoms and two died in Plot B1 (N), while one showed clinical symptoms in Plot C (K). In addition, one animal, transferred from Plot A (Mg+N) to Plot B1 (N) exhibited the definite

hyperæsthesia often noted preceding the more active symptoms of grass tetany. This occurred 12 days after the transfer and at the time a blood sample was being taken.

The two fatal cases on Plot B1 (N) in 1953 died with little warning in spite of the frequent observations made because their serum magnesium levels were known to be dangerously low. Winnie 21 was a little uneasy at the afternoon milking (4.0 to 5.0 p.m.) but gave a normal yield of milk. No symptoms were noted during the evening, but at 11.0 p.m. she was found dead. Dorrit 24 appeared in no way abnormal at the afternoon milking and gave a normal yield, but was found dead on her plot at 8.0 p.m. In neither case was tetany observed, but evidence on the plots suggested that convulsions preceded death.

Flora 99 in Plot C (K) showed the typical symptoms including initial hyperæsthesia followed by tetany and prostration.

Curative treatment. As stated previously, curative treatment was adopted as soon as clinical symptoms of grass tetany appeared and in some cases where a condition of hypomagnesæmia persisted without clinical symptoms. Initial subcutaneous injections of 200 ml. of a 25 per cent solution of magnesium sulphate with or without calcium borogluconate, followed by daily drenching with either 2 oz. (approx. 56 g.) magnesium oxide or 2 oz. calcined magnesite containing approximately 87 per cent magnesium oxide, normally promoted a rapid recovery in blood magnesium levels, and in the behaviour of the animal. Milk yield was often severely depressed for a day or two after symptoms occurred, but usually returned to near the previous level remarkably quickly. Supplementary concentrates were also fed.

In 1952 three cows (Kate, Sarah 3 and Pippin 14) were dosed with 4 g. MgO daily for 12 days during the period when the blood magnesium levels were falling. In one case, Pippin 14, this treatment appeared to check the decline in the serum magnesium during this period, but in the other two cases, the fall continued and one animal showed clinical symptoms. At the end of this experiment six animals with fairly low serum magnesium levels were transferred to another sward and three of them dosed with 16 g. MgO daily while the other three were not dosed. Both groups showed a steady recovery in serum magnesium levels but in the three dosed animals the recovery appeared to be a little quicker. The difference between groups, however, was small and the meagre evidence concerning doses of about $\frac{1}{2}$ oz. MgO daily, or less, suggest that quantities of this order are not very effective. This trial was carried out late in the season and the inconclusive results may have been partly due to the spontaneous return of serum magnesium values to normal physiological levels.

Changing cows from one sward to another. The effect of changing cows from one sward to another was investigated in both years. In 1952, three cows from Plot A (Mg+N) which for 23 days after turning out to grass had shown serum magnesium levels about 2.0 to 2.5 mg. per 100 ml. were changed to Plot B (N). In two of the animals, Campion 17 and Charis, a rapid fall in serum magnesium quickly took place, while in the other, Leda 29, the previous slight downward trend continued.

In 1953 it was possible to change five cows from Plot A (Mg+N) to Plot B1 (N) at the same time as four cows were changed in the reverse direction. The rapid fall in serum magnesium of all five cows going on Plot B1 and concomitant rapid rise in all four cows going on Plot A leave no doubt as to the very great difference in the two swards in their effect on the incidence of hypomagnesæmia.

Chemical composition of the swards. The calcium, magnesium, phosphorus and crude protein contents of the herbage from the plots are given in Table 1. On each plot the samples were taken at about ten random points immediately ahead of the folding wire, on seven occasions in 1952, and on 10 occasions in 1953. While, for any one plot, a bulked sample on a single occasion would be an unreliable guide for the whole period of the experiment, since the sward would vary somewhat and would change with growth, the mean of all samples on each plot would give a fairly reliable indication of the average mineral and protein content of the sward on offer.

A major factor affecting the mineral content of a sward is the relative proportion of grass and clover since the latter normally contains a higher proportion of calcium and magnesium. In both 1952 and 1953 at one sampling near the end of the experiment a sample of grass and of clover was taken separately from each plot. The calcium, magnesium and phosphorus content of these samples are given in Table 2. The greater magnesium content of the clovers as compared with the grass and the even greater difference in calcium content, are very evident.

In Table 1 it is seen that the magnesium content of the herbage from Plot A (Mg+N) was substantially higher than for the other plots. In spite of no further application of magnesite the difference in magnesium content of this plot compared with the others was even greater in 1953, due possibly to the fact that too little time had been allowed in 1952 for absorption of magnesium into the sward. In view of the much higher content of clover in Plot C (K) in 1952 than in 1953, it is surprising that the mean content of magnesium is only a little higher in the first year. On the other hand, there is a great difference in the calcium content of the sward on this plot in the two years.

The crude protein content of the sward was substantially increased by the application of sulphate of ammonia. On Plot C (K) in 1952 and Plot B1 (O) in 1953, where no nitrogenous fertilisers were used, the crude protein content of the herbage was on average still up to about 20 per cent in the dry matter, due partly to the clover present. Even in Plot C (K) in 1953, when the clover had been suppressed, the dry matter contained an average of 17.5 per cent crude protein which would adequately cover the animal's requirements for protein.

The range in the crude protein content of the herbage of each plot from one sampling to another is very wide. This is mainly due to the fact that the experimental period covered a period of rapid sward growth when the protein content of the dry matter normally falls rapidly. In some cases the percentage crude protein in the dry matter fell from over 30 per cent to below 20 per cent in about three weeks. There is little evidence of a direct correlation

TABLE I

Calcium, Magnesium, Phosphorus and Crude Protein content of mixed sward

(as percentage in dry matter)

	CaO		MgO		P_2O_5		Crude Protein	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
1952 (7 samples)								
Plot A (Magnesite + Nitrogen) ...	0.47	0.43 to 0.53	0.41	0.28 to 0.58	0.99	0.89 to 1.12	17.36	12.74 to 22.43
Plot B (Nitrogen)	0.53	0.45 to 0.59	0.25	0.23 to 0.31	1.29	1.05 to 1.47	22.79	17.66 to 30.62
Plot C (Potash) (Clover abundant)	1.14	0.80 to 1.60	0.27	0.23 to 0.31	1.07	1.00 to 1.14	20.42	14.03 to 24.95
1953 (10 samples)								
Plot A (Magnesite + Nitrogen) ...	0.51	0.42 to 0.60	0.57	0.50 to 0.64	1.01	0.92 to 1.09	25.64	19.65 to 31.93
Plot B1 (Nitrogen)	0.56	0.46 to 0.70	0.29	0.24 to 0.36	1.19	1.09 to 1.37	28.00	21.95 to 35.72
Plot B2 (Control)	0.77	0.53 to 1.00	0.28	0.24 to 0.35	1.06	0.93 to 1.23	19.88	14.01 to 24.66
Plot C (Potash) (Clover depressed)	0.61	0.48 to 0.79	0.22	0.21 to 0.29	0.99	0.90 to 1.18	17.50	14.37 to 22.90

TABLE II

Calcium, Magnesium and Phosphorus content of grass and clover separately

(as percentage in dry matter)

	CaO		MgO		P_2O_5	
	Grass	Clover	Grass	Clover	Grass	Clover
1952						
Plot A (Magnesite + Nitrogen) ...	0.34	1.74	0.32	0.63	0.74	0.98
Plot B (Nitrogen)	0.43	1.75	0.23	0.60	1.12	1.33
Plot C (Potash)	0.44	2.17	0.23	0.39	1.03	1.31
1953						
Plot A (Magnesite + Nitrogen) ...	0.33	1.51	0.24	0.88	0.89	0.99
Plot B1 (Nitrogen)	0.62	2.03	0.24	0.43	1.09	1.32
Plot B2 (Control)	0.59	2.05	0.26	0.38	1.00	1.20
Plot C (Potash)	0.53	2.03	0.21	0.39	1.03	1.20

between the crude protein level in the sward and the incidence of hypomagnesæmia either on a plot treatment basis or on a time basis.

Discussion

Before discussing the above findings it is useful to outline the unpublished results of three other experiments carried out concurrently but mainly for another purpose on the N.I.R.D. farms. In 1952 a study was made of the calcium, magnesium and phosphorus content of the blood of 24 dairy heifers (14 to 18 months old) on turning out to grass from indoor winter feeding. The sward concerned had, in previous years, caused severe hypomagnesæmia in lactating cows. It was similar to that on Plot B (N) except that the nitrogenous fertilisers used were equivalent to about 3 cwt. instead of 6 cwt. sulphate of ammonia per acre. Eight of these heifers received no addition to an all-grass diet, eight were dosed daily with 4 g. MgO and eight with 16 g. MgO. The interesting point about this experiment was the absence of hypomagnesæmic tetany even in the animals receiving no magnesium oxide. No animal showed a value below 1.0 mg. Mg per 100 ml. blood. Although the evidence is not direct, the results obtained suggest that young stock are less susceptible than milking cattle to the factors causing grass tetany at Shinfield.

A second investigation initiated in 1953 and designed to compare the milk production from different grass species provided evidence that the occurrence of tetany was not confined to a particular species of grass. In this experiment 12 cows were turned on to 12 separate plots, four each of perennial ryegrass and clover, meadow fescue and clover, and cocksfoot and clover. Unfortunately, severe hypomagnesæmia was not anticipated, and no blood samples were taken from these cows. Within seven days, however, typical clinical symptoms of grass tetany had occurred as follows:—

Perennial ryegrass, 1 case, Meadow fescue, 2 cases, Cocksfoot, 2 cases (including one death).

In a third investigation the serum magnesium levels were observed in 16 cows half of which were grazed on a perennial ryegrass sward (S.23) from which the clover had been eliminated, and a system of liberal nitrogenous fertilisation applied, while the other half grazed on the same ryegrass from which the clover had not been eliminated and on which nitrogenous fertilisers were used only as a basic dressing in the spring. In this case cows conditioned to grazing were used and the work carried out from mid-May till mid-June. No difference in the serum magnesium levels of the cows in the two groups was found and, in fact, no animal showed severe hypomagnesæmia. Since these plots were immediately adjacent to others on which grass tetany had occurred earlier, it seems likely that a major factor contributing to hypomagnesæmia had disappeared. This is in line with previous observations by Allcroft (1947*a* and 1952) on the seasonal occurrence of the condition.

Bearing in mind these three investigations, it appears, therefore, that the hypomagnesæmia which occurred in the main experiment was associated with the sudden transfer to spring grazing; was dependent in part at least on the

animals being in milk, and was not entirely dependent on a particular grass variety. Apart from this, there seems no doubt that the condition was strongly associated with the heavy use of sulphate of ammonia, although not an inevitable outcome of the use of this fertiliser, since, when 6 cwt. were applied to Plot A (Mg+N) in 1953, little hypomagnesæmia and no clinical cases occurred. The occurrence of hypomagnesæmia and one case of grass tetany on Plot C (K) in 1953, is of interest, since it falls in line with Brouwer's (1952) findings. It must, however, be borne in mind that in 1953 Plot C (K) may have received the effect of residual nitrogen from the strong clover growth of the previous year, particularly after the suppression of the clover before grazing in 1953.

The experiments do not contribute much evidence regarding the fundamental cause of hypomagnesæmia. It has been suggested from time to time that the condition may be the direct effect of a dietary deficiency of magnesium. The grass intake of individual animals in the main investigation could not be determined but from other work it is known that cattle of the type used, when on an all-grass diet consume on average about 30 lb. dry matter per day. On this basis, and using the data from Table 1, the daily intake of magnesium from the various plots would be as follows:—

1952	
Plot A (Mg+N)	33.7 g. Mg
Plot B (N)	20.5 g. Mg
Plot C (K)	20.5 g. Mg
1953	
Plot A (Mg+N)	46.8 g. Mg
Plot B_1 (N)	23.8 g. Mg
Plot B_2 (O)	23.0 g. Mg
Plot C (K)	18.9 g. Mg

It might be argued that the intake of over 30 g. of magnesium daily on Plot A was sufficient to prevent severe hypomagnesæmia, and that the cows on Plot B in 1952 and Plots B_1 and C in 1953 were receiving insufficient magnesium. This, however, would not account for the absence of severe hypomagnesæmia in Plot C (K) in 1952, and in Plot B_2 (O) in 1953. In addition, Ender, Halse and Slagsvold (1949) found that daily intakes of only 9 to 11 g. magnesium per cow did not necessarily give rise to hypomagnesæmia, and recent work by Parr and Allcroft (1953) showed that daily intakes of magnesium as low as approximately 4.7 g. daily, did not produce significant hypomagnesæmia in two-year old heifers on either high or low energy diets. On the other hand, the absence of grass tetany on Plot A which provided a high daily intake of magnesium, and the rapid recovery in serum magnesium levels following daily dosing with 2 oz. MgO (approx. 34 g. Mg) on other plots, indicate that the boosting of the daily intake from about 20 g. to 40 or 50 g. magnesium per cow rectified or prevented a condition induced by factors other than a simple shortage of magnesium. There is also the possibility that the beneficial effect of the magnesite dressing in Plot A may have been due to an alteration in soil

conditions resulting in the absence of "tetany-producing" factors in the herbage, rather than to the increased magnesium content *per se* of the sward. These possibilities, together with the indication that climatic stresses can precipitate hypomagnesæmic tetany (Allcroft, W. M., 1947*b*) and the fact that serum magnesium values can fall to dangerously low levels within 48 hours of ceasing to give magnesium-rich supplements to cows grazing "tetany-producing" pastures even though the supplements had been administered daily for several weeks previously (Allcroft, R., 1953) lend support to Green's contention (1939) that hypomagnesæmia in cattle is caused by a dysfunction of the physiological mechanism controlling blood magnesium levels rather than to a deficiency of magnesium in the diet.

In the experiments described no records were kept of the proportion of grass and clover on the various plots. It was evident, however, that hypomagnesæmia was almost entirely confined to conditions where little clover was present. This may be partly due to the fact that the grass contained only about one-half as much magnesium as the clover but the lack of direct correlation between hypomagnesæmia and the magnesium content of the sward suggests either that clover possesses other properties protecting against hypomagnesæmia or that factors so far unspecified, which depress clover growth in favour of grass, also increase the risk of a low serum magnesium level. This agronomic aspect of the problem appears to merit further study.

Summary

Milking cows were turned directly from indoor winter feeding to an all-grass diet grown with the following fertiliser treatments.

1952 Plot A—25 cwt. magnesite plus 6 cwt. sulphate of ammonia per acre.
Plot B—6 cwt. sulphate of ammonia per acre.
Plot C—4 cwt. sulphate of potash per acre.

1953 Plot A—no further magnesite but 6 cwt. sulphate of ammonia per acre.
Plot B_1—6 cwt. sulphate of ammonia per acre.
Plot B_2—control—no further dressing.
Plot C—4 cwt. sulphate of potash per acre. In this plot the clover was suppressed with a hormonal spray in 1953.

Of nine cows turned out on Plot A (Mg+N) in 1952 and 1953, none showed symptoms of grass tetany, and one only showed a substantial drop in serum magnesium levels.

Of 15 cows turned on to Plot B (N) (1952) and Plot B_1 (N) (1953), 11 showed severe hypomagnesæmia (at or below 0.6 mg. Mg per 100 ml. serum) and of these, five showed typical symptoms of grass tetany and two others died suddenly. In four other cows, turned on to Plot B (N) (1952) but with supplementary feeding with concentrates, the hypomagnesæmia was much less severe, and no clinical symptoms were observed.

In Plot B_2 (O) (1953) where no sulphate of ammonia was applied, the serum

magnesium level of three cows remained within the normal range, while that of the fourth fell only slightly.

In Plot C (K) little hypomagnesæmia appeared in 1952 when the sward contained much clover, but in 1953 the blood magnesium levels dropped in three out of four cases below 1.0 mg. Mg per 100 ml. serum, and clinical symptoms of grass tetany were observed in one animal.

Acknowledgments

To Mr. David Terrill for general management of the cattle; to Mr. Colin Line for taking and drying sward samples and to Mr. C. W. Clarke for technical assistance with chemical analyses.

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DISSEMINATION OF ANIMAL DISEASE IN INDIA. ROLE OF MAN AND OF CARRION FEEDERS

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THERE are a number of intermediate agencies which may disseminate infection from carcases of animals which have died from such diseases as anthrax and those due to sporing anaerobes. The most important of these are human beings, carrion-feeding birds and mammals; smaller agents such as flies, ticks, ants and coprophagic beetles play a subsidiary part. It is of some general interest to be able to recognise the carrion feeder, and some notes are given of its habits and methods of working. Such observations cannot be looked on as a preliminary attempt to take some action against the carrion feeder. It is better to recognise the existence of infection early enough to remove danger by burial. It may often be impossible to do this and recourse must be made to the provision of an efficient veterinary service which by organised schemes of vaccination or other means of control may in time drastically reduce the number of diseased carcases.

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Human Beings

When an animal dies in the rural districts of India, the owner informs the *chamar* or low-class trader in skins and meat, who, in the case of cattle, transports the carcase on a bamboo pole to a spot a mile or so from the village. There, the *chamar* skins the carcase, taking the hide for sale and possibly some of the flesh for his own consumption; the remainder is left for vultures and dogs. The knives and other implements used for skinning are washed in a nearby tank or stream provided there is no objection from the villagers. A few days later the bones are collected by village dealers, loaded in gunny bags and sent away for marketing. The *chamar* is not usually expected to pay for the carcase though he may make odd contributions to owners by providing or repairing cheap footwear. Small animals, such as sheep, may be skinned in the *chamar's* house and the bones are sometimes made into a mixture which is used for tanning. In some Moslem communities in what is now West Pakistan, (Baluchistan, N.W. Frontier Province, Sind, Punjab), the procedure may be rather different in that the *chamar* himself does not come into the picture. The owner, with assistance, may drag the carcase to an open space near the village and skin it. The hide is washed free of dirt and blood, dried in the sun and sold in the market for a small sum; the skinned carcase is left wholly to vultures and dogs. In some of the more enlightened Moslem villages, the carcase, after being skinned by the owner in an open space near the village, is handed over to a *chamar* who is paid in kind a nominal wage for the labour of dragging the carcase farther away; here it is buried roughly or even burnt.

Carrion-Feeding Birds

The distinction between beasts of prey and carrion-feeding is not quite sharp, as the former may be forced by hunger to eat carrion. A description of carrion-feeding birds is given in publications by Jerdon (1862-64) and Dewar (1913) and also by Stuart Baker (1928) in the last edition of " Fauna of British India." A very readable account of the vultures with means of identification when at rest and on the wing is also given by Donald (1918-21).

Vultures belong to the order *Accipitres,* Family *Egyptidæ,* and are confined to the tropical and warm temperature regions of Africa, Asia and Europe. Though vultures are unmistakable as such, the various species are not always easy to differentiate from one another. The head and neck are bare, or only partly covered with down, and there are no true feathers on the crown. This is the common feature of all species and is the only distinctive character by which vultures may be distinguished from falcons, eagles and hawks. The bill is very strong and laterally compressed, with a hooked tip. Vultures commonly fly at great heights and for discovery of food they depend on their eyesight and are guided by movements of birds below. They feed exclusively on carrion, though it is stated they may begin feeding on a sick animal before it is dead. After engorgement vultures prefer to rest a while and such a bird is seen in the background of Fig. 4 resting on its belly after a meal. If, however, they are forced to fly immediately after a large meal, they often disgorge part of it.

Fig. 1. Vultures feeding on skinned buffalo carcase

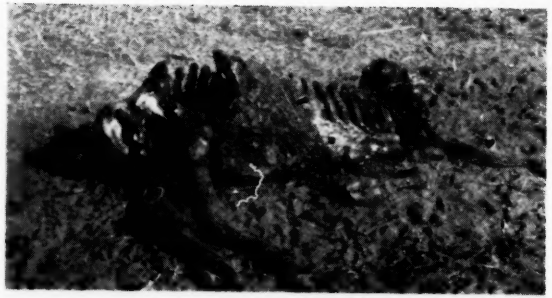

Fig. 1a. After 10 minutes feed

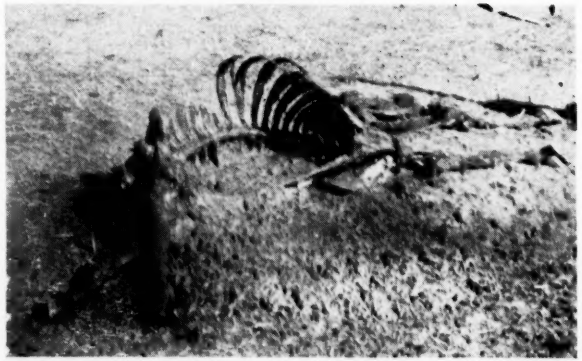

Fig. 1b. After 22 minutes feed

Fig. 1c. Another view of vultures feeding on skinned buffalo carcase.

(Article by Minett, page 19)

Fig. 1d. Skeleton after 15 minutes feeding

Fig. 2. Vultures feeding on unskinned buffalo

Fig. 3. Vultures feeding on unskinned buffalo. Stage 2.

(*Article by Minett, page* 19)

Fig. 4. Vultures feeding on unskinned buffalo. Stage 3

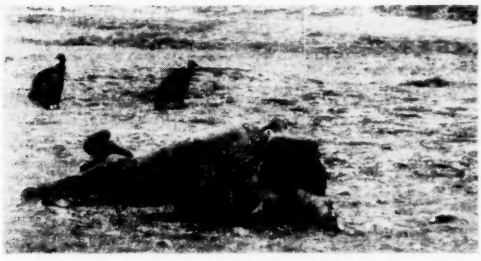

Fig. 4a. Buffalo carcase after vultures feeding. The ground around is strewn with feathers.

Fig. 5. Excrement of vultures in vicinity of carcase

(*Article by Minett, page* 19)

PLATE IV

Fig. 6. Goat carcase. Portion of intestine drawn from enlarged anus by crow

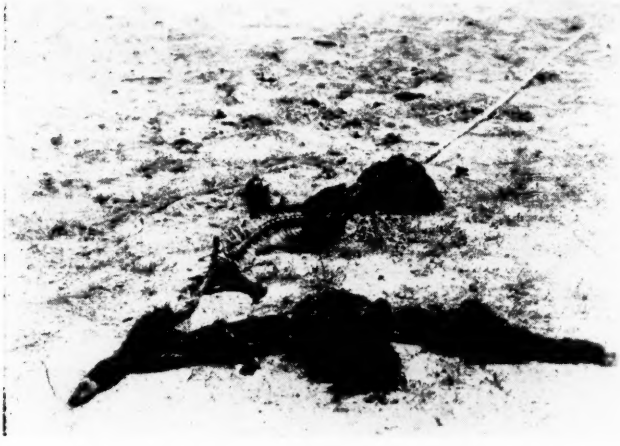

Fig. 7. Sheep carcase. Overnight feeding by jackals

Fig. 8. Goat carcase remains after 55 hours. Untouched for first 25 hours

(*Article by Minett, page* 19)

The types noted on the plains of Northern India were :—

Pseudogyps bengalensis (Indian white-backed vulture). It is the most numerous and its body feathers are ashy black; in the resting bird the white lower back is nearly or quite concealed by the untidy-looking wings. It has a wing span of about 25 in.

Gyps fulvus fulvescens (Indian griffon vulture) is distinguished by having khaki-coloured feathers, by its larger size and more pugnacious nature. Very few of these birds are seen in the crowd attacking a carcase.

Gyps himalayensis (Himalayan griffon) is very like *G. fulvus* and was identified in a shot specimen at Mukteswar.

Sarcogyps calvus (black, king or Pondicherry vulture) is a striking bird and bears some resemblance to a turkey, having head and neck and lower unfeathered part of the leg dark-red; the plumage is mostly black but with some white on the chest and thighs and flattened folds of red skin hang each side of the neck. It is nowhere very abundant and one or two usually come to feed with scores of others.

Neophron ginginianus (scavenger vulture) which of its small size, is sometimes not recognised as a vulture. It is a common sight near human habitations and acts as a scavenger of human fæces. These birds also feed on scraps from animal carcases after most of the large vultures have had their fill, and if undisturbed will tear carcases in the usual way.

Gypaëtus barbatus hemachalanus (Himalayan bearded vulture, or Lämmergayer) bears much resemblance to an eagle, but zoologically is intermediate between eagles and vultures. This bird is said to work at altitudes up to 20,000 feet or more.

Other common feeders observed were :—

Milvus govinda (pariah kite), *Corvus* sp. (house crow, jungle crow) and *Acridotheres tristis tristis* (common myna). All these feeders will peck at carcases persistently, provided they are undisturbed by vultures and dogs. Otherwise, they have to be content with scraps, which may be transported for more leisurely consumption. Crows also consume flies as they feed on the carcase.

Leptoptilus dubius, Gmalin (Adjutant stork). Two of these birds appeared in Izatnagar in May. Their bills are obviously not adapted for tearing carcases, but the birds wander about among the vultures, keenly watching for scraps and even seizing these from the vultures. These storks are not pugnacious but they can swallow large chunks of flesh or skin.

Observations on these carrion-feeding birds were made at Izatnagar and Mukteswar, with skinned or unskinned carcases of buffaloes, sheep and goats, and the following summaries are given :—

(1) In an experiment at Izatnagar in February, 1945, the skinned carcase of a buffalo was exposed at 9 a.m. After about 150 vultures had congregated the attendant who was guarding the carcase allowed them to approach. In a few seconds the carcase could not be seen for dust and for the crowd of vultures tearing at it (Fig. 1). The birds appeared to be mounted two deep on the carcase, all were fighting for a place at the feast and there was much

scrimmaging for pieces torn away. Birds at the periphery frequently plunged into the struggling mass. This was allowed to continue for 10 minutes and, after the remains had been photographed, for a further 12 minutes. Much of the body had been consumed after 10 minutes (Fig. 1a), while after 22 minutes little more than bones were left; the rumen had disappeared, and ingesta lay scattered over the ground (Fig. 1b). By this time, 250 vultures could be counted, mostly *P. bengalensis* and a few *G. fulvus* and the head, neck, wings and legs of many of them were red with blood. The birds took no notice of a pariah dog trying to "nose in," but they edged away when human beings approached to within two or three yards. Much the same story is depicted in Figs. 1c and 1d. The latter figure shows the remains of a skinned buffalo after 15 minutes feeding by upwards of 350 vultures.

(2) When a large unskinned animal such as a buffalo is exposed under similar conditions, the story is different. A male buffalo was thus exposed at 11 a.m. on March 21 at Izatnagar and birds began their attack at the orbit and at the natural openings, namely the mouth, nostril, prepuce and anus; this was carried on with much fighting by relays of about ten birds, in fact, by as many as could get a chance of approach (Fig. 2). The openings were gradually enlarged; at the anus it was up to 8 in. in diameter (Fig. 3) and was still more at the prepuce. The latter opening was then further enlarged so that a bird could pass easily into the abdominal cavity (Fig. 4). Birds not immediately occupied with the feast rested nearby, in anticipation or in silent satisfaction. By 5 p.m. the abdominal wall had collapsed and much of the interior had been consumed. At 7 p.m. a "tripe-hunt" was in progress, and crows assisted by collecting scraps. The feast was still proceeding at 9.30 p.m. in the moonlight and a large number of birds were crowded together a few yards from the carcase. Next morning (8 a.m.) 150 vultures were counted and two were working inside the carcase; 22 vultures only remained at 5 p.m. and the skin was then still largely intact. After three days' exposure the tail had disappeared and the left fore limb had been detached, possibly by jackals; both fore limbs were detached by the next day and the bones were lying 15 yards from the carcase. A few vultures, up to 15 in number, remained in attendance up to four days after exposure of the carcase, by which time there were myriads of flies. The ground was littered with feathers for yards around the carcase and was spattered with fæces and urine (Fig. 5).

In another experiment, the carcases of a hill-bull and of a buffalo calf of about the same size were exposed 15 yards apart. The former was then skinned and assembled vultures were allowed to attack at 1 p.m. After 15 minutes all but the skeleton was consumed and shortly afterwards, the birds detached the fore limbs and one hind limb. At 2 p.m. the buffalo carcase was still largely intact, but vultures were tearing at the pelvic contents through the enlarged anal opening; the eyes had been pecked away and they were tearing at the nose. About 200 *P. bengalensis*, 40 griffons, four *S. calvus* and two storks were attending the feast in addition to one dog, a few crows, some *Neophron*, and one veterinary officer carrying out supervisory duties.

(3) Some experiments were arranged to observe the habits of the birds when water is close at hand. A small pond was constructed, 9 in. deep and 5 ft. square, and a fresh skinned buffalo carcase was placed 10 yards away. After the feed the pond was a strong source of attraction for the vultures which came for drinking. A few of them slipped into the pond and splashed about extending their wings and ducking their heads. Crows also commonly drink or wade through the water after the meal.

(4) Two experiments showed, as perhaps might be expected, that vultures display no obvious choice as between fresh and putrid (buffalo) carcases.

(5) It has been said that vultures will not attack the dead of their own kind and this question has often been discussed. It is of no great importance to this enquiry but several observations were made which show that vultures will not readily consume their own kind, unless forced to do so by hunger. Two freshly shot and unopened vultures placed on the ground were clearly repellent. Two dead vultures, with the pectoral skin reflected, were placed on the ground beside skinned buffalo flesh (whole carcase or hind limb); the birds were very timid in their approach but they eventually consumed the flesh without touching the dead birds. This experiment was repeated several times. Nevertheless, bits of vulture flesh thrown to the birds were swallowed greedily.

In a final observation, four vultures were kept in a room without food for three days, when two dead but fresh vultures with breast muscles exposed were offered. Within half-an-hour feeding began and the two carcases were finally consumed.

(6) Unskinned carcases of smaller animals like sheep and goats were exposed in a place where vultures are rare, on the hills at Mukteswar. In this area carrion feeders, as kites and crows, behave like vultures in their habit of attacking a carcase at the eyes and through the anus (Fig. 6). They differ only in being less numerous, less powerful and more easily satisfied. Small unskinned carcases may have openings made directly into the chest, or through the flank, so that the birds may tear out and devour the intestines. Should the animal have died of anthrax and the weather be warm the bacilli thus exposed may have plenty of time to form spores before some more powerful feeder finds the carcase and disseminates the infection (Fig. 8).

Carrion-Feeding Mammals

Since jackals (*Canis* sp.), feed mainly or solely at night, their habits cannot be observed so well. It is clear, however, that the attack on an exposed, skinned or unskinned carcase of sheep or goat may be made by 40 or 50 of these animals at one time; not only are the flesh and organs consumed but there is also much dismemberment of the carcase, and broken or unbroken limb bones, from which flesh has been removed, may be found yards away (Fig. 7). The whole carcase may be dragged considerable distances and parts may be missing. Feeding may be continued on a second night. Jackals do not make such rapid progress with a large, thick-skinned carcase, such as a buffalo. It is

XUM

then a case of gnawing or chewing at certain parts rather than an attempt at gross dismemberment and exposure of the interior.

In addition to kites and crows, the domestic or pariah dog is an important carrion feeder on the hills; this is especially near habitations and in the absence of the numerous vultures found on the plains. The wild dog (*Cuon* sp.) attacks the living only but is said to eat carrion, if obliged to do so.

Discussion

The extent to which carrion-feeding birds can soil the exterior of their bodies with infective material from carcases of animals dead from septicæmic diseases has to be seen to be fully realised. This results in gross contamination of neighbouring water pools and must be a far more important source of spread than the excretion of infective material by the gut. In the case of anthrax it probably makes little difference to the ultimate result whether a large carcase is skinned or not. With black-quarter, where the infectivity of the body tends to increase after death through multiplication and sporulation of the organism in the slowly-cooling body (Minett, 1945), delayed multilation of an unskinned carcase may somewhat increase the available infective material.

A final point concerns the part played by carrion feeders in carcase disposal under eastern conditions. There is much to be said for the broad view that the danger of carrion-feeders and especially vultures as spreaders of disease is very greatly outweighed by the effectiveness with which they keep the countryside free from putrefying carcases. A special point concerns the disposal of large carcases in an Institute like that at Izatnager which produces large amounts of rinderpest serum and hence has a large output of healthy buffalo carcases. This disposal has always been a considerable problem. Cremation is out of the question and burial is very laborious. It would seem that, with effective supervision, a secluded area might well be set apart, where the carcases could be skinned and simply left for the vultures. The bones could be collected and sold periodically. This would be a highly efficient, safe and inexpensive method of disposal.

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THE INCIDENCE OF FUNGI IN THE LUNGS OF POULTRY

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Moulds are frequently isolated from the lungs of poultry which are apparently normal, and their significance is always a matter of doubt, especially in cases of difficult diagnosis.

The object of this work to inquire into the mycological flora existing in the macroscopically-normal lungs of birds which had died and were presented for routine post-mortem examination.

Method

Carcases were taken at random, opened asceptically, and the lungs examined *in situ*. If they appeared normal both lungs were transferred to a sterile mortar and sliced with scissors; if lesions were observed the material was discarded for the purpose of this investigation. Normal lungs were ground with sterile sand and saline and a loopful sown on to each of three media:—Sabouraud's medium, basal culture medium, and 2 per cent maltose extract agar. A total of 25 carcases were examined in this way.

The plates were incubated at 25° C. for eight days and examined daily. Occasionally a mould appeared which on continued incubation seemed likely to spread over the whole surface of the medium and in such circumstances incubation was discontinued. The inoculum on each plate was examined for the presence of fungus colonies. Yeasts were examined by film preparations stained with 10 per cent Nigrosin and cultures made from all the different colonial forms. These were submitted to Dr. Ainsworth for identification. Occasionally, two or more colonies of the same species but of differing colonial form were submitted from the same material.

Results

The fowls examined varied in age from 10 days to 5 years. In one case only, was death attributed to a mycological infection. In this case the abdominal air sacs were infected with *Aspergillus fumigatus* but the lungs were apparently normal, although *A. fumigatus* was isolated from them.

Penicillium species were found in 18 of the 25 lungs examined, whilst *A. fumigatus* was next in frequency, being isolated from 7 (Table I).

Of the 25 birds examined, 3 yielded no fungi. The remaining 22 gave a total of 37 cultures of 9 different species, with up to four species from a single pair of lungs.

A wide variety of species of fungi were thus isolated and it is possible that their incidence and variety would have been greater had a larger amount of lung tissue and a greater number of birds examined. There appeared to be no association between the age of the bird and the variety and number of fungi isolated.

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XUM

TABLE I

Incidence of fungi in the normal lungs of 25 fowls

Species of fungus	No. of birds from which isolated
Penicillium (18)* species alone	7
„ and *A. fumigatus* (7)	5
„ and *A. glaucus* (4)	3
„ and *A. glaucus* and *A. candidus* (2)	1
„ and *A. versicolor* and *A. candidus* and *Mucor* (2) and *Phycomycetis* (1)	1
Penicillium and unidentified yeast (4)	1
Unidentified yeast alone	2
„ „ and *A. fumigatus* and *Mucor*	1
A. fumigatus alone	1
No fungi isolated	3
	25

*Figures in brackets after each species when it first appears in the table indicate the total number of occasions on which it was isolated.

Summary

The macroscopically-normal lungs of 25 fowls were examined mycologically and a variety of fungi isolated.

Acknowledgments

I am indebted to Dr. Ainsworth of the University College of the South West, Exeter, for identifying the yeasts and fungi isolated and to Mr. G. D. Davies, A.I.M.L.T., of this department for technical help.

IMPERFECT FUSION OF THE STERNUM IN A CHICKEN AND A DUCK

By P. N. COWEN

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Gross malformation of the sternum in poultry, apart from bent keel, seems to be rare. The present case in a chicken was the first of its kind to be seen in a large flock of breeding chickens and their offspring kept at the Institute of Animal Genetics and Poultry Research Centre for over a period of 20 years. A related condition in a duck is also described.

Description

A Brown Leghorn male chicken (A4659) was hatched on March 31, 1952. Abnormality was first noted when it was six weeks old. The keel appeared to be absent and the sternum deficient in the mid-line. The heart-beat could be

seen through this gap. The animal seemed to be healthy and otherwise normal and it was kept in a pen with others where it survived very well. When it was 11½ weeks old, its growth appeared to be slightly retarded and it was sacrificed for examination.

Apart from the sternum, the only other abnormality consisted of numerous pericardial and peritoneal adhesions. The skeleton was then macerated in order to obtain a specimen of the bones. The keel was found to be absent and the rest of the medial process of the sternum was represented by two unevenly curved plates of bone which were not fused in the mid-line. The left plate overlapped the right superficially and by about ½ cm. in the mid-line and fibrous tissue connected them at this region. The other sternal processes were normal. Since the bird had been undersized, all the bones were smaller than normal. These features can be seen on the right in Figures 1 and 2 (ventral and lateral views respectively). The same views of normal bones from a chick of the same age, sex and breed are shown on the left for comparison. As well as the sternum, the coracoids, scapulæ and clavicle are shown in their relative positions. One interesting feature is that the hypocliedium of the clavicle is placed very close to the sternum, depressing the medial part of the right sternal plate. The hypocliedium is deficient at this situation. The deficiency in the mid-line of the live chick, through which the heart-beat was felt, was due to the inverted V-shaped deficiency between the caudal ends of the sternal plates. Two prolongations of cartilage extending caudally and medially were present but were destroyed during the preparation of the bones.

Although very few ducks are hatched at the Poultry Research Centre, a somewhat similar condition has been observed in one of them. An adult male Khaki Campbell was found to have a deficiency in the mid-line of the sternum through which the heart-beat was easily felt. It was thought, at first, to have a completely divided sternum, but on post-mortem examination of the skeleton, an incomplete fusion of the sternum (at its caudal end) was seen (Fig. 3). The normal duck sternum has a horizontal posterior border which, in this case, was represented by an inverted V-shaped notch. Apart from this skeletal deformity and a slight elongated heart no other abnormality was noted.

Discussion

The sternum in poultry is developed in cartilage (Lillie, 1927). Two lateral plates of cartilage grow towards the mid-line and first meet at their cephalic end. As growth continues, fusion takes place in a caudal direction. As soon as fusion takes place, the sternal crest (keel) is formed by growth ventrally in the mid-line. Thus at no stage of development is the entire sternum ratite. After the cartilaginous sternum has formed, five centres of ossification appear. One anteriorly in the mid-line and one pair each for the antero-lateral and abdominal processes. Complete fusion of the osseous sternum takes place at three months. In the specimens shown in Figs. 1 and 2, fusion has not yet occurred, the synchondroses being apparent.

In the case of the abnormal chicken, it would appear that the original

XUM

cartilage plates had not succeeded in meeting in the mid-line due to displacement of one of them out of its original plane. This would account for the overlapping of the plates in a continued attempt to approximate to each other. Furthermore, no keel could develop as a result of the failure to fuse. The plates of cartilage then ossified in this position. It is interesting to note that whereas there is normally only one centre of ossification for the medial process of the sternum, in this case, two centres must have appeared, one for each plate. The other processes seem to have ossified in the usual manner.

In the case of the duck, although the cartilaginous plates fused at the head end and formed part of the keel, it appears that they did not continue sufficiently in a caudal direction. The inverted V-shaped deficiency as seen in Fig. 3 therefore remained.

Rather than ascribe an independent mechanism for the malposition and malformation of the chicken's clavicle (Figs. 1 and 2), it would seem more plausible, to refer this to the sternal abnormality. As a result of the absence of the keel, the sterno-clavicular ligament gained attachment to one or both of the sternal plates in the mid-line. This caused the depressed position of the clavicle which rotated slightly in a dorsal direction about the scapulo-clavicular joint. The attachment of the muscle, pectoralis superficialis, to sternum and clavicle may possibly also have aided the clavicle to attain this position since in the normal, its attachment to the rostal tip of the keel would tend to draw the hypocliedium ventrally. On account of the close apposition of the hypocliedium to the sternum, the tip of the former either failed to ossify or it may have done so and then eroded. Whichever occurred, bony fusion between the two did not take place. Possible reasons for non-fusion are either that slight movement of the clavicle at the scapulo-clavicular point prevented it or the clavicle, being a membrane bone, does not have a cartilage precursor which might have fused with the sternal cartilage. On the other hand, fusion might have taken place later as the chicken grew older.

Only two reports of related conditions have been found in the literature. Dunn (1924) described a pullet with a caudal indentation of the sternum (resembling somewhat the duck reported here) and a more extreme case in a cockerel where the keel was absent, and the sternal division so extreme that only a slender remnant of the anterior portion of the median part remained to hold the skeleton together. The F_1 and F_2 of these defective birds were normal. MacLaury, Buckner and Insko (1948) reported one cockerel with a caudal cleft and an opening in the centre at the median process. No genetic data were reported. The fowl case described here was one of 89 birds hatched from the same mating, which was between two inbred lines. Not all were examined in detail, but no gross abnormality was recorded for any, thus supporting Dunn's suggestion that the condition is not genetic. There are at least two genes in mice, however, which are responsible for a bifurcated xiphisternum. One of them, the short-eared gene, is a simple recessive and causes arrest of development of ears and cranial bones and prevents complete fusion of the bilateral sternal cartilages prior to ossification (Green and McNutt, 1941). Varying

FIG. 1

FIG. 2

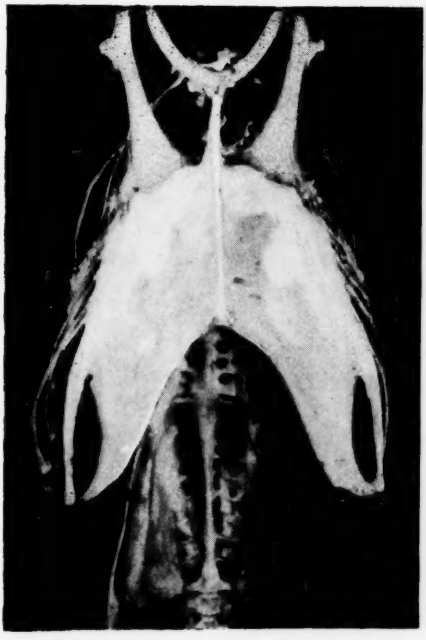

FIG. 3

(*Article by Cowen, page 26*)

degrees of split xiphisternum, not associated with short ears has been reported in the C57 black and leaden strains of mice and in 60 per cent of the Bagg albino strain (Green and Sawin, 1939).

Summary

A description is given of an abnormality arising in a Brown Leghorn chicken, consisting of non-fusion of the two lateral sternal elements together with the absence of keel. The clavicle was malpositioned probably due to the sternal deficiency. A comparable condition, but of lesser degree, is described in a duck. The abnormalities are discussed with particular reference to the development of the sternum. It is not known if any genetic influences were responsible.

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OBSERVATIONS ON THE OCCURRENCE OF *CNEMIDOCOPTES PILÆ*, IN BUDGERIGARS AND A PARAKEET

(Lavoipierre and Griffiths, 1951)

By J. N. OLDHAM and W. P. BERESFORD-JONES

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SINCE the publication of the paper by Lavoipierre and Griffiths (1951) dealing with the occurrence of scaly leg in a budgerigar caused by *Cnemidocoptes pilæ,* we have been able to isolate and examine mites from five out of six budgerigars showing mange-like lesions. The specimens consisted of gravid and immature females and larval mites and two male mites were recovered from one of the budgerigars and examined. Measurements of the females, which possessed a definitely chitinized dorsal shield completely covered with minute punctiform dots and with distinct edges, the occurrence of the adscutal setæ arising from a common base and other morphological characters corresponded with the description given by Lavoipierre and Griffiths for *C. pilæ.* The morphology of the males also agreed with that described by Lavoipierre (1953). We concluded, therefore, that the mites we were dealing with were *C. pilæ.*

The interesting feature of these infestations was that from none of the five budgerigars were mites recovered from the feet and legs; in fact, no lesions

occurred at all on the feet and legs of these birds. The parasites were found in hard, crusty and brittle scabs, whitish to yellowish in colour, that occurred at the junction of the beak and the feathers of the head in that region. The ages of the birds were assessed at from six to twelve months, and lesions occurred on both cocks and hens. No mites were recovered from the sixth budgerigar which showed a crusty condition at the base of the beak and on the legs.

Besides the budgerigars already referred to we had the opportunity to examine an Alexandrian parakeet (*Psittacula nipalensis*) suffering from feather picking and dermatitis. It showed loss of feathers around the neck, the ventral and mid-dorsal aspects of the body, and the skin of the legs appeared scaly. Mites having a morphology similar to that described for *C. pilæ* were recovered from skin scrapings taken from the neck region. About a month later the bird was re-examined and showed little, if any, improvement after treatment. A few feathers were plucked out and scrapings collected from the beak and neck and females mites were recovered from the scabby area around the feather follicles. The parasites corresponded with the description of *C. pilæ* and were similar to those seen at the first examination of the bird.

From these observations two points arise. Firstly, it would appear that *C. pilæ* is not confined to budgerigars and may have a wider host range than at first thought. Secondly, the mite is not confined to the shanks and the pads of the feet but can occur in other regions of the body, particularly at the base of the beak.

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ABSTRACT FROM CURRENT LITERATURE

THE POISONING OF SHEEP AT PASTURE*

THE few points collected together below and which deal with the poisoning of sheep at pasture may possibly be of interest to those working on the toxicology of plants.

From the Crimea, Komarov reports the poisoning of sheep due to their feeding on hay containing quantities of *Lepidium perfoliatum* and in which the mortality rate reached 25-35 per cent. The clinical symptoms included depression, loss of appetite, diarrhœa, weakness of the hind quarters and sometimes a nasal discharge. On post-mortem some bloody fluid was found in the lungs and bronchi but apart from a hyperæmia of the mucosa of the abomasum

* "Plants Poisonous to Sheep and Goats," *Refuah Veterinarith* (1950, Vol. 7, No. 1). *Veterinaria* (June, 1952).

and early degenerative changes in the liver there was nothing else worth recording. (*Veterinaria,* June, 1952).

Almeev describes the symptoms and post-mortem changes observed in sheep poisoned by *Aconitum rotundifolium* and which occurred at Issik-Kul in Kirgizia. The symptoms were manifested from 30 minutes to 24 hours after the ingestion of the plants and included weakness of the extremities, unsteady gait, local cramps, rigidness of the muscles of the head, body, neck and extremities. Later there was grinding of the teeth, an absence of the corneal reflex, disturbance of the heart action, coma and paralysis of the urethral and anal sphincters. Mortality was up to 100 per cent. (*Veterinaria,* June, 1952).

In an interesting Hebrew paper appearing in "Refuah Veterinarith" for April, 1950, Dr. Hareubeni refers to a number of poisonous plants found in Israel. *Ferula communis* is found widespread around Mount Ephraim and in the Akron district and in these places the Arab shepherds consider it very poisonous to goats, the sheep not being affected: sheep brought in from the surrounding areas will eat the plant and die. At the beginning of spring an unknown plant is the cause of poisoning in the flocks. It is thought that this is probably Ferula.

The early rains bring on plants which are regarded as injurious to sheep and goats and among these are *Malva rotundifalia* and *Avenua sterilis* which have undoubtedly been the cause of poisoning. It is recorded that a number of sheep died near Jaffa after eating *Nicotiana glauca* and *Sorghum annuum* is also on the list of suspects. *Eryngium glomeratum* has been used in cases where stock has been poisoned maliciously and *Belleralia* which grows in the deserts of Judea is regarded by the local shepherds as very poisonous to both sheep and goats.

R.H.A.M.

REVIEWS

How Animals Move, by James Gray. London: Cambridge University Press. Price 16s. net.

A healthy animal moves with a grace and efficiency which delight the eye. If it be sick or ill, be it in body or limb, then that grace and efficiency is lost and the change affronts the eye.

Many men can recognise that which is abnormal but the normal or common state often passes without recognition or comment.

Abnormalities of gait resulting from accident and disease or defects in conformation are of great concern to Veterinary Surgeons. Some surgeons achieve great proficiency in the arts of diagnosis and treatment. Few can disclose or impart their skill to others and it must be presumed that their success depends more on some degree of fortuitous intuition rather than on logical con-

XUM

cept. It is obvious that if one is well founded in the knowledge of what is normal and reasonably versed in the laws of mechanics which govern movement then the art of diagnosis and treatment of ambulatory disorders could be placed on a sounder footing and raised from the realms of empiricism. Professor James Gray gave some lectures at the Royal Institution at Christmas, 1951. They attracted great attention and this book, in which his ideas, explanations, and theories are made available to a wider audience, is the sequel.

It appears that all movements in animals are governed by certain simple laws of mechanics and in chapter one under the heading "The Machinery of Animal Movement" he introduces the reader, and with clarity, to the simple rules which are involved.

To explain his points he makes use of such common objects as wheels and motor cars.

This chapter sets the standard for the book and in the subsequent text the author explains in simple and concise language the various types of movement which can be observed in certain terrestrial, airborne and aquatic animals. The reader may have no fears that these dissertations on mechanics may be above his comprehension for Professor Gray demonstrates that he possesses the greatest attribute of a good teacher. He uses simple language, his descriptions are lucid, and the many illustrations have been selected with great care.

Veterinary Surgeons will find his remarks intriguing and they can read the book with profit and pleasure.

FARMER AND STOCKBREEDER YEAR BOOK 1954. 78th Edition. London: Farmer and Stockbreeder Publications Ltd. Price 10s. 6d. (postage 6d.).

THE traditional idea that those who work on the land depend upon good health, a robust physique and plenty of luck in their fight with the elements, receives its death-blow when one turns the pages of this book.

A modern farmer is all the better if he be blessed with good health and luck, but he also requires to be a politician, a scientist, an economist, an engineer and to have a reasonable knowledge of the law if he is to keep out of trouble, make a success of his life and job, and remain solvent.

Since 1939 agriculture has sheltered under the umbrella of governments impelled to benevolence by necessity. Farmers have prospered as they did in other critical times, for example in the Napoleonic Wars and during World War I. The time has come when food is no longer in short supply in the world and the ships are beginning to move with regularity. Controls, subsidies, and the necessity for favourable treatment are coming to an end. Agriculture has to be orientated to stand on its own economic feet and there is some anxiety abroad.

There are some who like to be led and do not object to "shackles." They do not welcome the restoration of freedom and the privilege of planning their own destiny. Tristram Beresford deals with the political and economic facets of the "new emancipation" in an intriguing article entitled "Freedom—But

for What?" Whilst giving all the pros and cons of the arguments for and against "controls and liberty" he does not indicate definitely on which side he stands.

Farmers must realise that "the piper calls the tune" and in this case "the piper" is the consumer. The consumer is also the taxpayer, and he demands that agriculture like any other industry should now shoulder its own problems and troubles, and gain its economic reward not from the taxpayer but in proportion to the service it provides to the community.

There are other articles on more precise professional lines dealing with techniques and methods.

(1) "Profit from Silage," by Professor James Morrison.

(2) "Grass as a Senior Crop," by William Davies.

(3) "Foreign Threat to British Pig Breeders' Prosperity," by Colin Brett.

(4) "Winners in the Race for the best Barleys," by F. R. Horne.

(5) "Johne's Disease," by T. M. Doyle.

(6) "Deep-freeze Preservation of Semen," by A. Robertson and L. E. Rowson.

(7) "New Foods Cannot Replace Good Management," by H. R. Bird.

(8) "Simple Sheep Husbandry," by W. R. Seward.

(9) "Modern Machinery," by W. R. Seward.

Then there is a special Poultry section, and G. G. Belfield writes on "Hybrid Layers" and W. M. Justice on "Broiler" production.

We have purposely enumerated this list of articles for each and all are of good value, and the authors represent a galaxy of talent. Farmers will profit if they read and digest the valuable information compressed into these pages.

As is the custom, the Pedigree year is illustrated by most beautiful photographs which gladden the eye and make one proud of our stockmen. No other country could produce such a variety of magnificent animals. It is plain to see why Britain is the "Stock Nursery" of the world, but it is sad to note that our horses are relegated to the last four pages.

The remainder of the text is in the nature of a Farmers' reference encyclopædia and it would be difficult to pose a query, apertaining to any branch of the industry to which one could not find either the correct answer or the information where that answer can be obtained.

IODINE FOR SMALL ANIMALS. London: Chilean Iodine Educational Bureau.

IODINE is an essential of animal life and deficiency of this mineral gives rise to physical and mental abnormalities. This small booklet indicates how to feed iodine to the domestic pets and gives a tabulated brief review of its uses on the various species.

XUM

THE AGRICULTURAL NOTEBOOK, by Primrose McConnell. 12th Edition. Edited by Professor H. Ian Moore, Principal Seale-Hayne Agricultural College. London: Farmer & Stockbreeder Publications Ltd. Price 35s. Net.

PRIMROSE MCCONNELL'S Agricultural Notebook was first published in 1883, and it has remained a popular reference book ever since that date. The many editions reflect the great changes that have taken place in the agricultural economy during the last 60 years, and in this the 12th Edition Professor Moore and his team of experts have brought it up to date according to present practice. It is amazing that such a wealth and variety of information can be packed into such small compass, and it would be difficult to cite any agricultural topic or query which was not discussed or answered in its pages.

No doubt this fact is responsible for its great popularity, for it brings the wealth of a great library to the farmhouse.

Veterinary surgeons will find it to be a useful vade-mecum for reference.

THE HORSEMANS' YEAR 1954. Edited by Lt.-Col. W. E. Lyon. London: Wm. Collins Sons & Co., Ltd. Price: 15s. net.

THERE is a strange fascination about horses and it weaves a spell to encompass and thrill the members of the human species, be they expert horsemen or women or just simple spectators who occupy a ringside seat. This book has achieved the status of an annual classic by which one can review all the outstanding equine events of the year whilst enjoying the sedentary comfort of a fireside armchair.

The 1954 issue is well up to the standard set in previous years. Col. Lyon has gathered together a good variety of articles written by acknowledged authorities and illustrated by a great profusion of most excellent illustrations.

Horsemen were delighted that the Coronation processions were accomplished with all their glory with the horse taking his traditional role. They will be intrigued by Capt. Frank Gilbey's account of how this great task was accomplished. Fred. Bason in "A Cockney sees the Point," an account of his first visit to a point-to-point meeting, will cause many a chuckle. The appendix giving the results of important races under N.H. rules and also the placings at the "classic" shows is of historical value and will settle many future arguments.

The Horsemans' Year would make a grand present for any devotee of the horse.

SUPPLEMENT TO THE S.F.A. CATALOGUE OF MEDICAL FILMS. London: Harvey and Blythe. Price 6s. net.

VISUAL methods of teaching are of great value in our schools and colleges and especially so in medical and veterinary institutions. A remarkable collection of films, dealing with almost every facet of the medical curriculum is

now available and in this catalogue they are listed in sections under appropriate headings. Short reviews are given of the subject matter and the time and length of the film.

The catalogue should be very useful to those teachers who wish to keep abreast of modern methods.

SPORTSMAN'S SKETCHBOOK. Lionel Edwards, R.I. London: Putnam & Co., Ltd. Price: 12s. 6d. net.

IN spite of the great advances that have been made in the photographic arts the end results cannot compare in vitality, grace and detail with that which comes from the hands of a gifted artist.

This is especially so when the subjects to be portrayed are animals. The best of photographs are flat and dead. In the artist's picture you can see behind and beyond. The subjects are vital and posed as they show best to the practised eye. Lionel Edwards's horses and hounds need no eulogy and one could well imagine that any of them in this book could walk off the page. Look at the grazing horses on page 20. I am sure that someone has "rattled" his bowler hat. There are pencil sketches of the National Stud, of coaching horses and stables, and of the stable yard at an inn which are grand. Some pictures are in colour also but in my opinion the pencil sketches surpass these.

Horsemen will appreciate this small book and will profit from the study of each and every picture.

NEWS

WE are advised by the British Veterinary Association that as from Friday, December 18, 1953, their address has been changed to 7 Mansfield Street, Portland Place, London, W.1. New telephone number MUSeum 6541.

ERRATUM

"The Climatic Environment in the Modern Piggery" article by D. W. B. Sainsbury and A. C. Dunkin in December, 1953 issue; The authors regret an error on page 499, line 5.

The temperatures given as 22° F. and 33° F. should be 20° F. and 30° F. respectively.

XUM

OBITUARY

As we go to Press we regret to hear of the passing of Dr. F. C. Minett.

Dr. Minett had been ill for some months, and, as our readers will note, he kept at work almost to the end.

Publishers' Notices

THE BRITISH VETERINARY JOURNAL, with which is incorporated THE VETERINARY JOURNAL, is published monthly, and copy for advertisements should be in the hands of the advertisement manager not later than the 20th of the preceding month, if proof is required. Tel.: Temple Bar 3386.

Letters for the Journal, literary contributions, reports, notices, books for review, exchanges, new instruments or materials, and all matter for publication (except advertisements) should be addressed to the Editor.

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